Climate Change in NC: Crops, Land Price and Water

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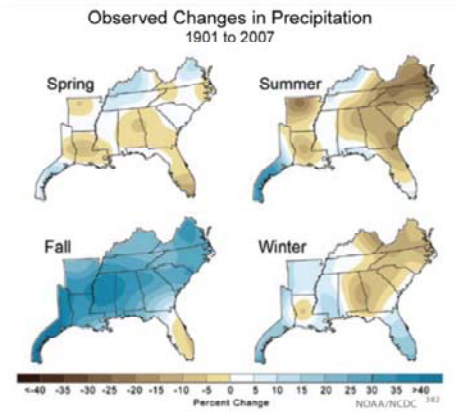
Climate and Land Values

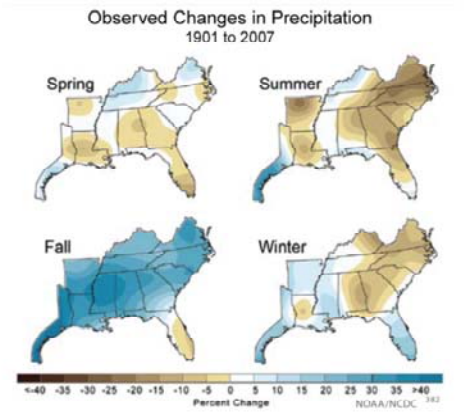


- Large climate shifts since 1900
- Precipitation in Southeast has increased by about 30%
- Parts of NC, however, have seen 30% decreases in summertime precipitation

Today I want to discuss the relationship between agricultural production, land values and future climate change. Then we'll get into the role of water. Climate change is a politically charged term, so I want to be clear that I'm talking about climate change in the sense of changing patterns of weather over time, not climate policy, Green New Deal, carbon emissions, etc. I want to talk about what scientists are predicting might happen to climate over the next 60 years and how that might affect agricultural output, profitability, and land values. And, what can maybe be done about it in terms of adaptation. Why adaptation? Because farmers are always adapting and changing and oftentimes the science doesn't properly account for this, which I'll talk about momentarily. First, however, I want to draw your attention to climate change, 1900 to today.

Climate and Land Values

$$Value = \frac{Rent_1}{1+r} + \frac{Rent_2}{(1+r)^2} + \frac{Rent_3}{(1+r)^3} + \cdots + \frac{Sale_n}{(1+r)^n}$$



- Large climate shifts since 1900
- Precipitation in Southeast has increased by about 30%
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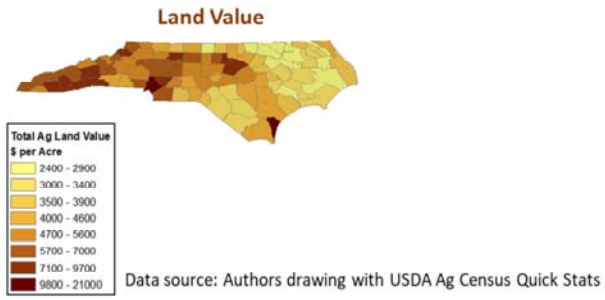
So here is an equation, the only one of the presentation, which is an economists view of agricultural land value: the sum of the rents you earn from your land, over time, put into current year value (e.g. a dollar tomorrow is no worth as much as a dollar today), every year until the land is sold. Keep this equation in mind, we'll revisit.

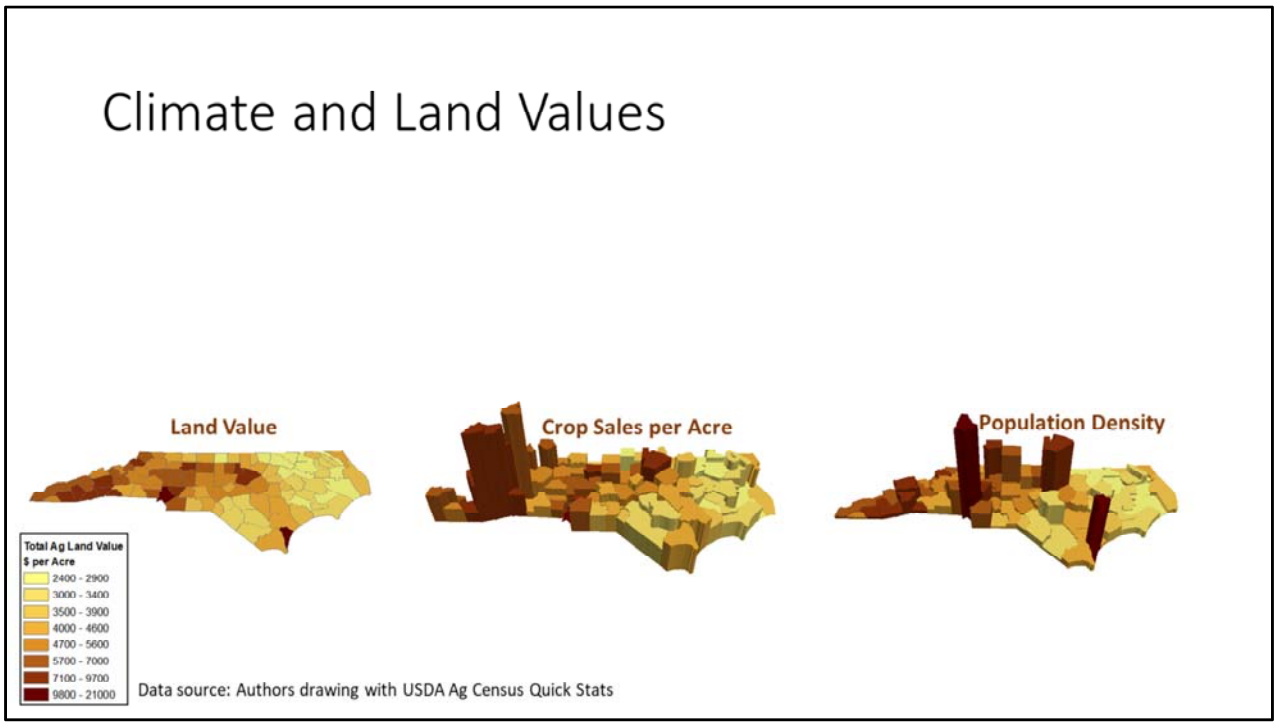
Climate and Land Values



Data source: Authors drawing with USDA Ag Census Quick Stats

Key to this presentation is understanding how agricultural land values are related to climate and water. To understand the relationship, it is important to understand how economists think about land value. Land value per acre is related to both the value of crops the land can produce, and its potential to be converted out of agriculture and developed. Notice where in the state ag land values are high. In eastern North Carolina as well as some counties that, if you look closely, contain the state's largest cities.

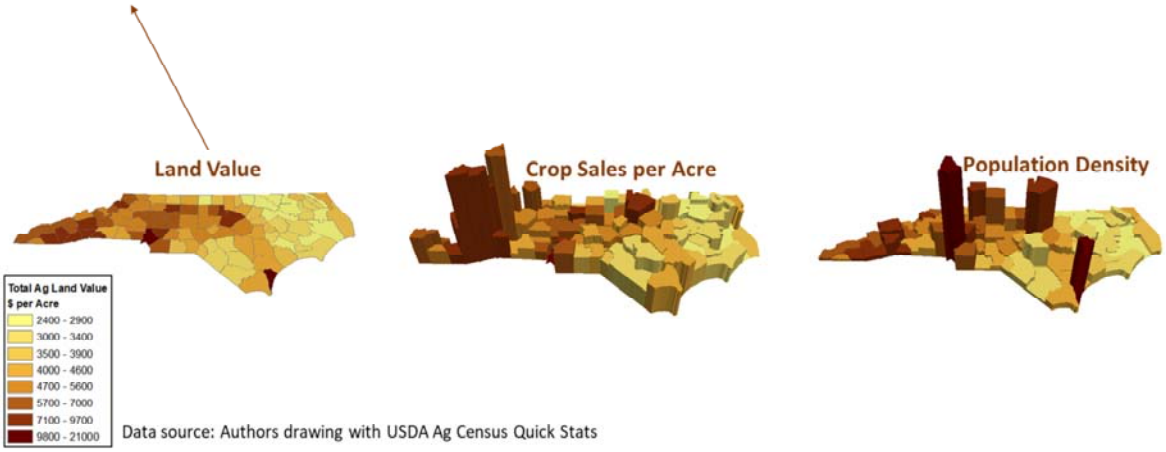
The second figure is the same as the first but the elevation of each county is proportional to the crop value produced per acre. This explains the high price of agricultural land in the western part of the state, high value produced per acre. Of course, there aren't many acres in production in this part of the state, but those that are are valuable.



The third figure is the same as the first, but with the elevation of each county related to the population density. This explains the ag land value of the counties around the Triangle, Charlotte, Winston-Salem, and Wilmington.

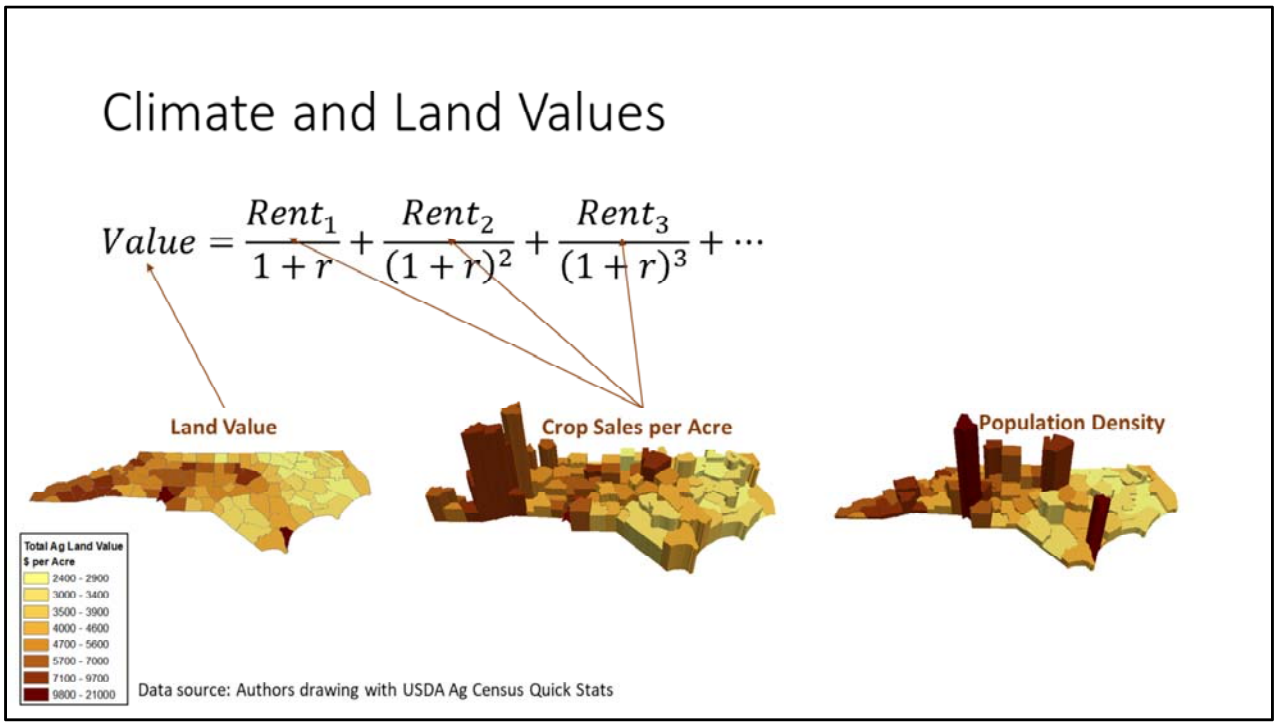
Climate and Land Values

$$Value = \cdots$$



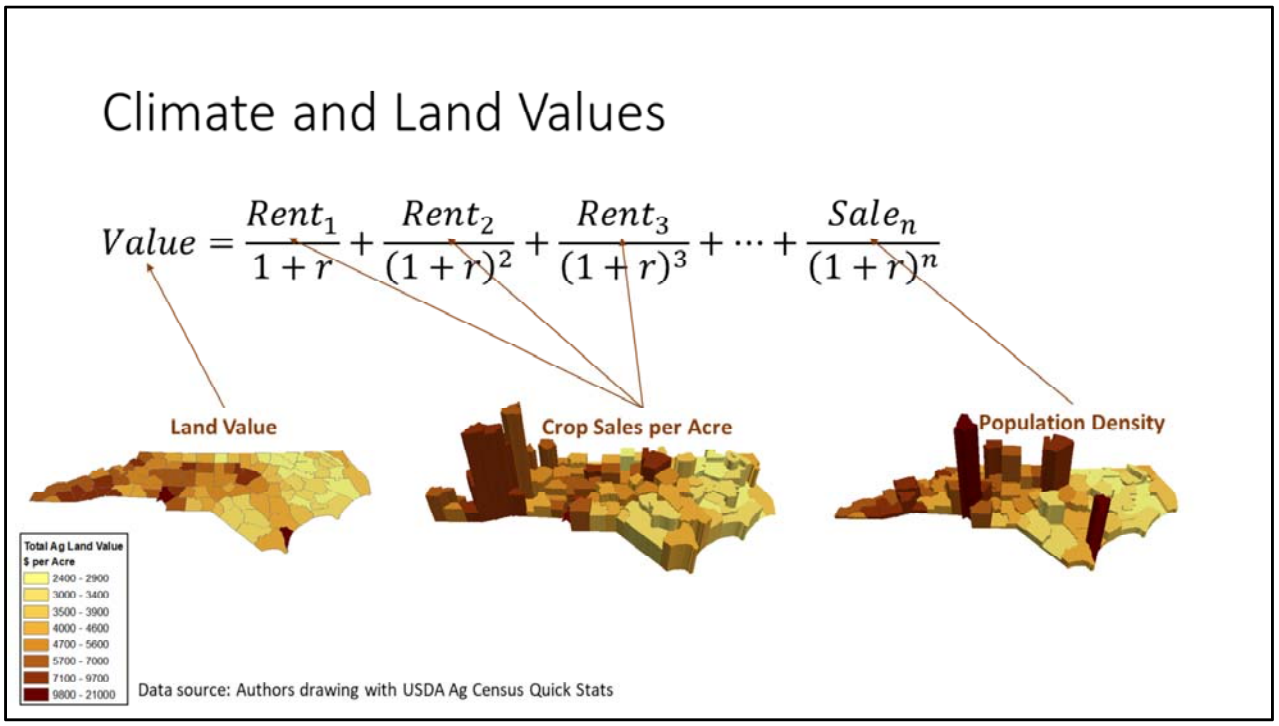
Data source: Authors drawing with USDA Ag Census Quick Stats

We can write an equation for the value of land, where value will be a function of land rents and conversion value.



We assume land earns cash rent each period that is related to the value of crops it produces. Better land in a better location produces more valuable crops and therefore the rent paid on the land is higher. (If you're farming your own land, the rents are implicit, but still if you're producing better and more valuable harvests, your land will be worth more.)

Today, land is worth the discounted sum of all future rents. Discounting means that rents in the future are less valuable today than cash in hand today. Think about it as the interest payment on the land that is being rented. Although you're receiving cash rent, you need to pay the bank for the value of the land. Own the land outright? It's the same idea, only an implicit (opportunity) cost.



In addition to cash rents, at some point the land may be converted to a subdivision, gas station, etc. That sale value occurs after the sum of cash rents (you don't receive rents after you sell). The value of land being sold is related to population density. In Wake County, ag land demands a premium not because the soil or climate is better, but because there's a larger demand from non-agricultural buyers.

Climate and Agriculture

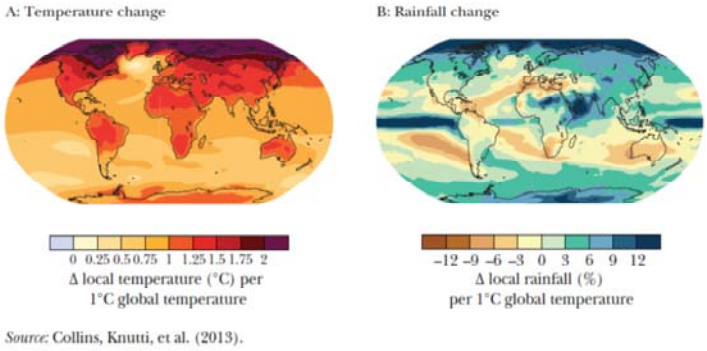
- Plant response to climate is affected by:
  - Carbon dioxide (CO2)
  - Temperature
  - Solar radiation
  - Precipitation
- Timing of changes is important
  - Temperature during pollination stage
- Water can moderate effects
- Extreme events: Temperature and storms

So, what's the potential effect of climate change? Plants respond to many factors that a changing climate and. Climate change is caused by elevated CO2, which also helps plants grow. Climate change will raise temperatures, which can help or hurt plant growth, and affects yields in non-linear ways. Temperature increase are energy increases, and the additional energy creates more ocean activity and evaporation. North Carolina is expected to get wetter and warmer. The additional energy in the system is expected to general more hurricanes and other large precipitation events. Additional moisture in the air also affects the amount of cloud cover, and thus solar radiation hitting plants.

Climate changes tells us something about how the weather will change, e.g. it will be hotter, wetter, etc. But the variation in weather over the day and year is also important. Crop yields are more susceptible to temperature and precipitation extremes at certain times. For instance, hot-temperature extreme weather events have a large effect on corn during the pollination stage.

Water can mitigate temperature effects. Misting apple orchards, for instance, can cool the trees enough during very hot spells to protect yields. However, water can also be the problem. Extreme events can inundate fields with water. But even heavier than normal precipitation can leave water tables too high for optimal crop growth.

Worldwide Climate Change Projections

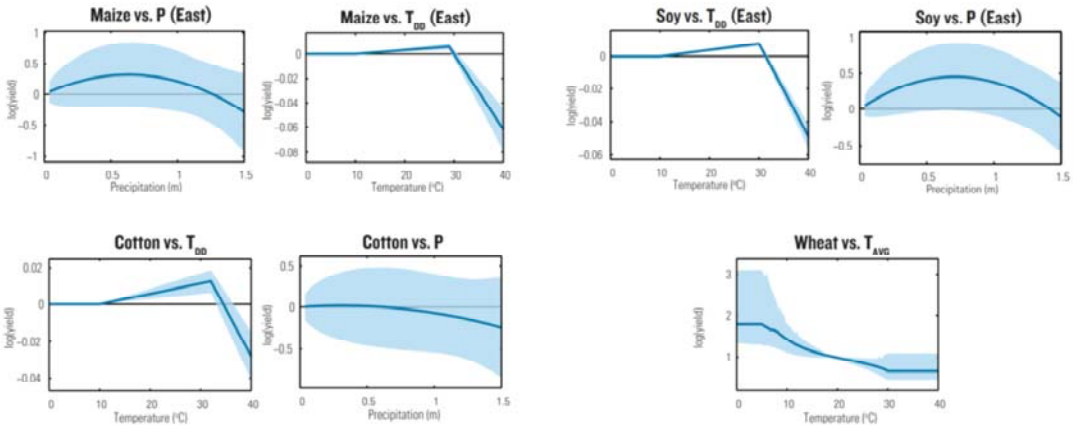


Source: Collins, Knutti, et al. (2013).

Scientists project the effect of climate using complex models that require massive computing power and a lot of assumptions. Generally, I don't trust the reliability of any one model very much. The map depicts the average warming at each location associated with a 1°C increase in global mean temperature; values greater than 1°C indicate rates of warming faster than the global mean, while values below 1°C indicate warming that is slower than the global mean. NC is right near that average.

This model isn't going to be "right," but it gives you a middle-of-the-road idea of what climate change wil llook like, and the consensus is for North Carolina that will be warmer and wetter, but with potentially more periods without precipitationin the summers.

Crops: Big-4 / Climate Relationship

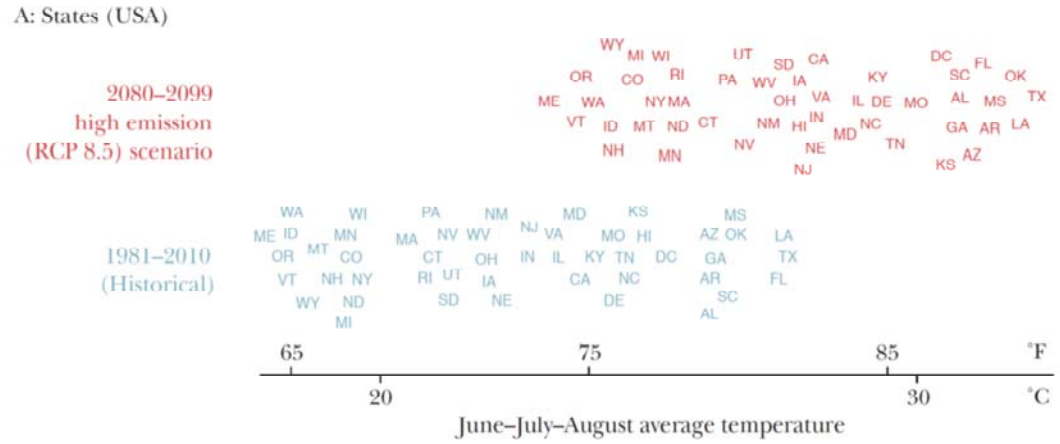


Source: Hsiang, S., Kopp, R., Jina, A., Rising, J., Delgado, M., Mohan, S., Rasmussen, D.J., Muir-Wood, R., Wilson, P., Oppenheimer, M. and Larsen, K., 2017. Estimating economic damage from climate change in the United States. *Science*, *356*(6345), pp.1362-1369.

How to translate projections of changes in precipitation and temperature to changes in crop output? In heir recent paper in science, Hsiang et al (2017) generate crop-yield to weather variable relationships. The yields are generally non-linear, meaning it's not a straight line. Generally, it's hard to grow something at 0 degrees but gets better as the temperature increases, until a point where it is too hot for the plant. The functions show yields as a function of seasonal rainfall and seasonal 24-hour temperatures. You can interpret log yields as percentages. A one degree temperature increase at some point on the chart leads to the blue line x100 percentage decrease in yield. For instance, increasing temperature from 29 to 30 degrees C for cotton increases yields by about 2%, but increasing temperature from 39 to 40 degrees C decreases yields by almost 3%.

Cotton—fairly heat tolerant
Soybeans—huge drop in yield with high heat

US Temperature Change Projections

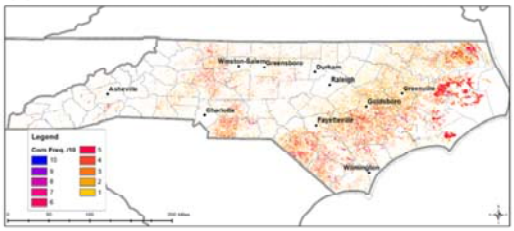


Source: Hsiang, S. and Kopp, R.E., 2018. An Economist's Guide to Climate Change Science. *Journal of Economic Perspectives*, *32*(4), pp.3-32.

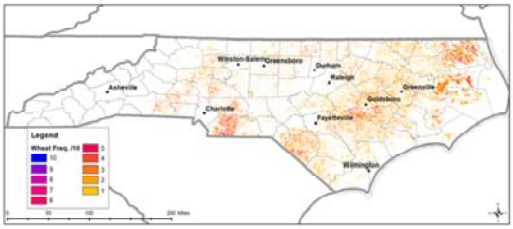
This chart shows how summer (growing season, typically) temperatures will change by 2080-2099. Summer temperatures in North Carolina by 2080 will be higher than those in Louisiana or Texas today in a high emissions scenario. Finding these types of projections for each county in the US is difficult and requires a lot of assumptions, it also leads to a lot of uncertainty. However, this doesn't mean that temperatures won't get hotter. It just means we're unsure how much hotter. Given these temperatures and out yield functions, we can calculate changes in crop production as a result of climate change.

10-year Crop Frequencies

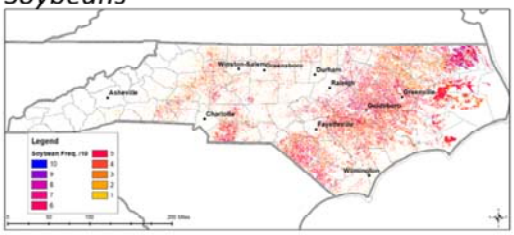
Corn



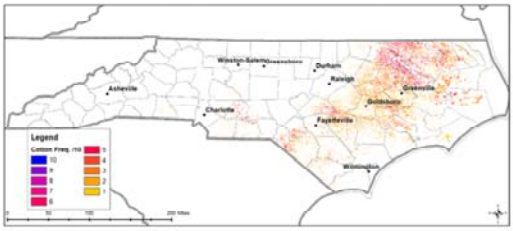
Wheat



Soybeans



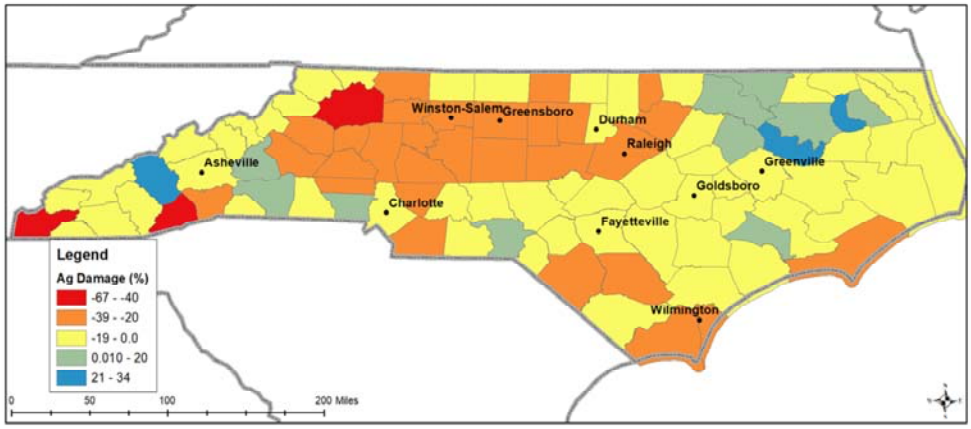
Cotton



Data source: CropScape - Cropland Data Layer. National Agricultural Statistics Service

Here's what happening in NC with ht ebig-4 crops right now. We plot the frequency of plantings for each type of crop over the last 10 years. Dark blue means the crop was planted every year. Yellow means it was planted once in the last 10 years. There is so much to unpack here, we're just going to focus on a few key trends. First, the NC cotton belt in the northern portion of the state, these counties are going to see climate impacts from changes in cotton yields. AS you'll recall, cotton is fairly heat tolerant. Second, lots of soybeans on the coastal plain. You'll recall soybeans had the highest negative yield response to high temperatures. Third, crop rotations. This implies farmers have some flexibility in what they plant—we'll get back to this. Finally, fourth, is the distribution of sales. The western part of the state doesn't grow much. You'll recall ag land was valuable in the west, but in aggregate there isn't much of it.

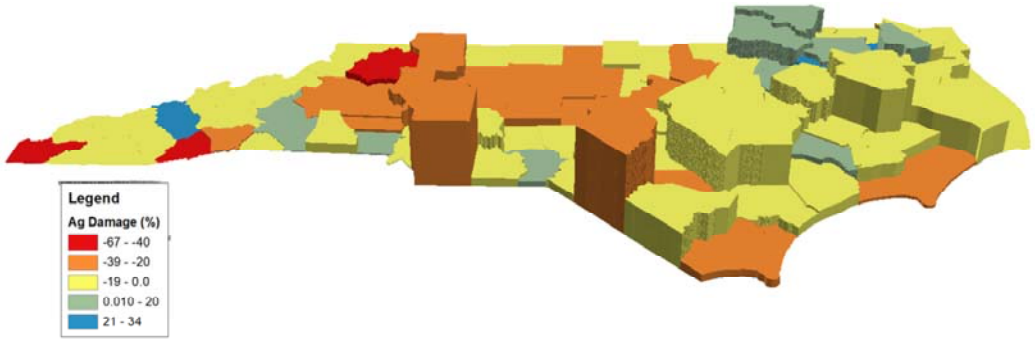
Big-4 Crop Yield Projections (2080-2099)



Data source: Hsiang et al (2017)

Taking htos yield functions and climate change projections to North Carolina counties, we arrive at this map of potential percentage losses. There is quite a range. Some counties expect yields an revenues to increase, others see losses over 40%. Note the cotton counties are blue and green, but much of the rest of the state faces losses. The large western losses are in percentage terms, but…

Damage Projections with Current Sales (Big 4)



Data sources: USDA Ag Census Quick Stats and Hsiang et al (2017)

When you plot the actual amount of sales as the county elevations, you see that the largest percentage losses are not large total sales losses. Instead, losses in sales are predicted to hit Orange: Union and Robeson. As well as the coastal plain growers who are not in cotton. Yellow (group 1): Sampson, Duplin, Wayne, Lenoir; Yellow (group 2): Beaufort, Pitt, Hyde, Washington. Benefitting the most in terms of sales are Green: Bertie, Halifax, Edgecomb, Northhampton.

Caveats / Questions

- Only Big-4
  - What about livestock?
  - What about specialty crops?
    - Sweet potatoes
    - Tree crops
    - Peanuts
- Assumes similar crop choice mix going forward
  - Change crops
  - Water management
    - Irrigation when dry, drainage when wet
    - High-precipitation events

Livestock – not included; generally do less well in heat, but not a county-level analysis yet.
Specialty crops – very valuable, typically more sensitive to temperature and precipitation—thus why we see pockets of these crops.
Big caveat is that the approach necessarily assumes a static allocation of crops.
Other investments in mitigation are possible, in particular farmers can do more to keep fields dry (drainage) and wet (irrigation)

Addressing Long-Run Changes in Climate

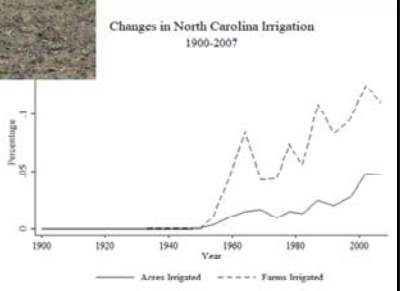
Drain Tiles

Drainage Ditches

Drainage can be improved by installing ditches or drain tiles as shown in the pictures. When water falls on a field and percolates into the groundwater system, a low outlet, either buried like drain tile or open like a ditch, allows the water to flow underground off the land.

Studying Water Adaptation in NC

- Drainage
  - Current: 40 percent of the cropland requires drainage improvements
- Irrigation
  - Current about 5% of acreage and 10% of farms are irrigated

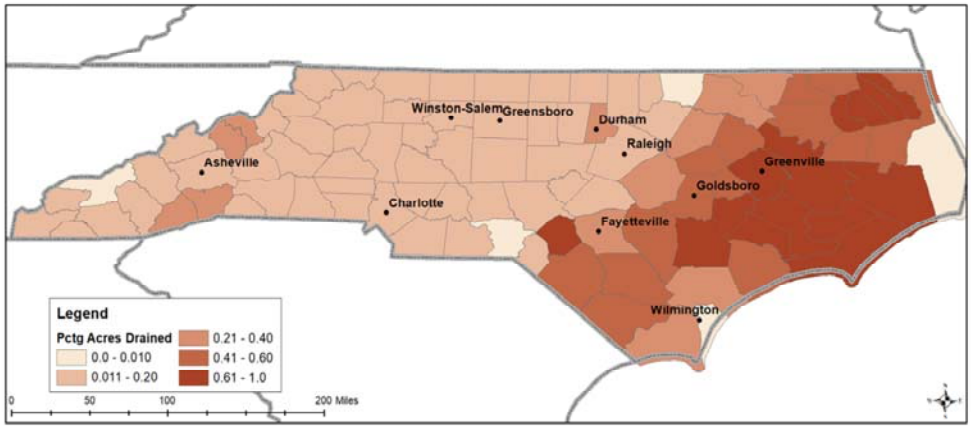


Already around 40% of cropland has drainage and 5% irrigation. But, potential to do more is possible. Irrigation has been gaining traction in North Carolina. About 10% of farms are irrigated as of 2012.

Mattamuskeet Drainage Company

Ake Wheeler Road NC State extension Research Facilities

Percentage of Crop Acres Drained

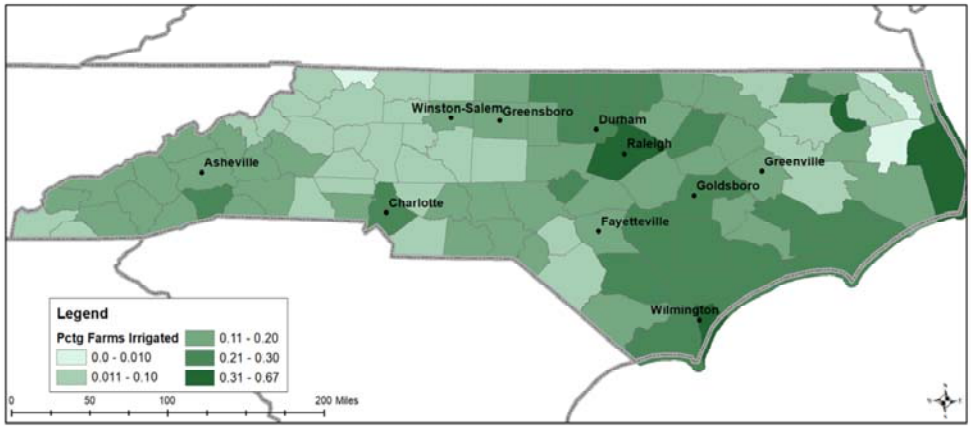


Data source: USDA Ag Census Quick Stats

The eastern part of the state is especially low and wet, making drainage an important adaptation.

Agricultural water management (water table management) for enhancing crop yield and reducing the negative water quality impacts of crop production on artificially drained agricultural landscapes using **controlled drainage and sub-irrigation systems**.

Percentage of Farms with Irrigation



Data source: USDA Ag Census Quick Stats

North Carolina doesn't need irrigation to grow crops, but it can provide important water source during periodic times when rainfall is low.

Extreme Events

Hurricanes and other extreme events are predicted to increase with climate change.

Drainage Issues

- Farm drainage also drains nutrients
  - Nitrogen and phosphorous
- Drainage takes lands out of wetland habitat
- Smart systems
  - Avoid draining right before a drought

Water Conservation / Water Quality

Falls Lake during the 2007-08 drought

Dan River coal ash incident

Urban water—matching supply and demand in variable climate. Empty reservoirs to avoid floods, or save water for drinking during drought?
Conservation pricing might be able to help communities match water supply and demand. See image of a completely empty Falls Lake during the 2007-08 drought. Recent work on this for Utah, but is relevant here in NC:
https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=2956&context=extension_curall

Coal ash—legacy ponds susceptible to breaches during large storm events. Same issue with hog lagoons, municipal wastewater facilities, and even septic systems on the coast. All potentially problematic under climate change.
Coal has seen a recent, rapid decline as a source of electricity in North Carolina. Unfortunately, coal's legacy lives on in ash ponds and landfills scattered across the state. In February 2014, 39,000 tons of coal ash spilled through a storm pipe break at the Dan River Steam Station in Eden, North Carolina. Awareness of the potential environmental and health impacts of coal ash skyrocketed. In this NC State Economist, we offer an economist's perspective on North Carolina's coal ash challenges – and potential solutions.
https://cals.ncsu.edu/news/should-i-stay-or-should-i-go-coal-ash-in-north-carolina/

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